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PATENT SPECIFICATION

Convention Date (Germany): Aug. 17, 1934.

460,912

Application Date (in United Kingdom): Aug. 7, 1935. No. 22311/35.

Complete Specification Accepted: Feb. 8, 1937.

COMPLETE SPECIFICATION

Improvements in and relating to Screw Propellers for Driving Air-craft and Water-craft

We, JUNKERS-MOTORENBAU, G.M.B.H., a Joint Stock Company organised according to the laws of Germany, of 39, Junkersstrasse, Dessau, Anhalt, Germany, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in and relating to screw propellers for driving aircraft and watercraft and in the case of watercraft relates to screw propellers for such craft whether adapted to rotate in air or water.

In the case of propellers for driving aircraft, it is known to provide automatic devices for varying the pitch of the propeller blades of such a kind that the number of revolutions remains approximately constant in the event of variations in the driving torque or resistance to rotation so that unduly low speed, with inadequate utilisation of the engine power (for example in starting), or excessive speed, with a dangerous increase in the number of revolutions (for example, in gliding or diving) are avoided. By exerting a suitable manual influence on the device (such as a centrifugal governor) responding to the changes in the number of revolutions (for example by modifying the tension of the governor spring), the controlled number of revolutions can be varied within certain limits. Such a device, however, has certain defects. If the supply of fuel to the motor be set so as to reduce the supply (idling position), by means for example of a hand lever connected with the throttle of the carburetter, the device adjusting the pitch of the propeller blades will then set the blades to minimum pitch, in order that the propeller speed remains, as nearly as possible, at the controlled number of revolutions. However, it is uneconomical to drive the propeller at the same speed, when the engine is throttled, as when the engine is fully charged, because, in such a case the efficiency of both propeller and engine is low. There is also the risk of the engine racing if the full charge of fuel be suddenly admitted again, because a certain time must elapse before the device for varying the pitch of the propeller blades has increased the pitch to the extent corresponding to the full engine torque and the excess of the engine torque over the reaction torque of the propeller during that period, has increased the number of revolutions.

The aforesaid possibility of varying the normal speed by influencing the governor spring by hand affords it is true a means for lessening these inconveniences, but it imposes a further task on the driver of the vehicle and there is also the possibility that just when danger arises, a wrong adjustment may be made and the evil increased instead of diminished.

The object of the present invention is to provide a pitch adjustment device which is automatic but which at the same time sets the pitch to the economically optimum degree both for running under full charge or with the fuel charge slightly reduced and idling, and at the same time completely relieving the driver of the vehicle from making the adjustments.

According to the invention the member of the pitch-adjustment device, which serves to modify the controlled speed is coupled with the accelerator member varying the supply of fuel to the engine in such a manner that the speed is reduced concurrently with the reduction of the fuel supply and vice versa. In addition, a device may also be provided for enabling the controlled speed to be modified at will within certain limits, independently of the supply of fuel.

The accompanying drawings illustrate various typical embodiments of the invention, together with a diagram explaining how it operates. In the drawings:

Fig. 1 is a perspective view in partial plan and

Fig. 2 is a similar view partly in section of a variable pitch propeller according to the invention.

Fig 3 is a diagram showing the dependence of the number of revolutions

[Price 1/-]

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on the setting of the member influencing the supply of fuel to the engine.

Figs. 4—6 represent in plan, various detail arrangements of pitch-adjustment devices.

As shown in Figs. 1 and 2, a hub 2 is secured on the propeller shaft having sockets 3 and 3^1 in each of which a propeller blade 4 and 4^1 is mounted so as to be rotatable on its longitudinal axis. The propeller blades carry lever arms 6, 6^1, connected by means of rods 7, 7^1 to a crosshead 8, which is adapted to slide in the direction of the propeller axis, on an extension 10 of the propeller shaft so that on the crosshead being displaced a twist is imparted to the propeller blades, thereby modifying their pitch. The crosshead 8 is adjusted by a centrifugal governor which shares the rotational movement of the propeller and consists of centrifugal bobs 13 seated on bell-crank levers 12 and of a spring 14 which acts against the centrifugal force and bears on the one hand against a collar 15 rigidly connected to the crosshead 8 and embraced by the levers 12 and on the other hand against a slidable abutment 16. The abutment 16 is displaced by a lever 17 the one end 18 of which is attached to a support 20 rigidly connected with the propeller hub 2 by means of the shaft extension 10 whilst the other end 19 of the lever engages one end of a rod 22 the other end of which is connected to a collar 23 rotatably mounted in an annular groove of an axially displaceable sliding member 25 surrounding the bearing 24 of the propeller shaft 1. The sliding member 25 is displaced by means of a rod 27, which is mounted on the body, for example in the bearing 26 and is attached to a two-armed lever 30 the two ends 31 and 32 of which are connected respectively to rockable control members 33 and 34. The control members carry spring pawls 41, 42 adapted to engage in corresponding notches in fixed racks 43, 44 so that they are automatically locked in their position for the time being. The control member 34 attached to the end 32 of the lever 30 is connected at the same time by means of the rod 35, with the member controlling the supply of fuel to the engine, for example a throttle 36 located in the pipe 38 leading from the carburetter 37 to the engine.

The arrangement operates in the following manner:

The control members 33 and 34 and therewith the abutment 16 of the spring 14 are assumed in the first place to be set in a definite position. In addition a condition of stability exists that is to say the centrifugal force of the governor bobs 13 and the tension of the spring 14 are mutually in equilibrium. In such a case no twist is imparted to the propeller blades 4, 4^1. If now, for any reason, for example owing to a change from horizontal flight to gliding, the propeller speed increases, the centrifugal governor will set up increased compression on the spring 14 and push the collar 15 further towards the right, the propeller blades 4, 4^1 being thereby set at an increased pitch angle, which, however, increases the resistance to rotation so that the number of revolutions does not further increase.

If on the other hand the propeller speed decreases, for example in changing from gliding to climbing, the tension of the spring 14 overcomes the centrifugal force and pushes the collar 15 towards the left, thereby twisting the propeller blades in the direction of lowering the pitch of the blades.

Consequently, the governor tends to maintain constant a given speed which is determined by the tension of the spring under all conditions of flight, namely a higher speed when the tension of the spring is increased and a lower speed when said tension is lowered.

The control member for modifying the supply of fuel to the engine is connected with the abutment 16 of the spring in such a manner that when the supply of fuel is reduced (fuel-saving or throttled flight), the tension of the spring 14 is reduced thus setting the governor for reduced controlled speed whereas on the supply of fuel being increased, for example in starting or climbing, the spring tension is increased and the governor therefore set for high controlled speed.

The result obtainable in this manner is that when a change is made in the supply of fuel by setting the control member 34 between full charge and an amount corresponding to a smaller charge, the pitch of the propeller blades is scarcely altered, the propeller therefore behaving (as shown in Fig. 3) like a fixed-pitch propeller in this range of charging so long as no disturbances occur. In modifying the supply of fuel between the large amount D (full charge) and the small amount B (low charge), the number of revolutions n vary approximately in accordance with the same law—represented by the line b—as a fixed pitch propeller. The automatic governing device, however, acts towards preventing the number of revolutions n^1 subordinated to any definite adjustment of the fuel supply such as Z^1, from being increased

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or diminished in the event of any disturbance but always maintaining the same constant by varying the pitch of the blades.

Independently of this action on the governor, in subordination to the supply of fuel, the entire range of control can be displaced in the upward or downward direction by adjusting the control member 33 as indicated by the lines b_1 and b_2 in Fig. 3. For example, it is often desirable, in adjusting for a large fuel supply, to increase the number of revolutions beyond that attainable according to line b in order to obtain temporarily the highest possible engine output. The reduction of the controlled speed shown by the curve b may be desired when one or more cylinders of a multicylinder engine fail, for example through ignition trouble and the supply of fuel to such cylinders cannot be shut off.

The governor could also be influenced independently of the fuel supply, the pivotal point 31 of the lever remaining stationary, by modifying the length of the rod 27, for example by means of an interpolated turnbuckle.

The speed range within which the automatic governing device will maintain a constant definite number of revolutions by twisting the propeller blades is restricted, especially in the downward direction, for constructional reasons. If therefore, for example, the speed n_1 forms this lower limit of the range of control and said speed corresponds to the position B of adjusting the supply of fuel to the engine, then if said fuel supply be further reduced, the governor would tend to maintain the speed n_1, in accordance with the line c, but the only way in which this can be done is by lessening the pitch of the propeller. For the previously mentioned reasons, however, i.e. risk of the engine racing when the setting is such that a considerable supply of fuel suddenly occurs, such lowering of the propeller pitch when the supply of fuel is small is undesirable. The invention therefore provides further means for preventing the pitch of the propeller from being lowered when the supply of fuel falls below the position B corresponding to the lower limit of controlled speed n_1.

Suitable arrangements for this purpose are shown diagrammatically in Figs. 4—6, these Figs. relating to propellers the blades of which are twisted by means of an auxiliary force, hydraulic pressure in the examples shown, controlled by a centrifugal governor.

In these examples the lever arm 6 on the propeller blade 4 is attached by means of connecting rod 7 and rod 40 to a power piston 42 adapted to travel in the cylinder 41. By means of a slide valve member 45 the admission and discharge into and from the power cylinder of the liquid delivered and subjected to pressure by a pump 50 are controlled the piston being accordingly displaced and thereby imparting a twist to the propeller blade 44. The valve member 45 is set by the centrifugal governor which shares the rotational movement of the propeller and embraces the collar 29 fixed on the valve rod 28 and in other respects is designed as in the example shown in Figs. 1 and 2 being also adjustable to different controlled speeds. Its parts are indicated in the same manner as in those Figs. The delivery pipe 51 leads from the pump 50 to the central space of the slide-valve casing 46 from the end spaces of which the pipes 52 and 53 lead back to the pump. Located between the delivery and return pipes is a spring-loaded safety valve 55. The valve casing and power cylinder are placed in communication by the passages 56 and 57 controlled by the valve member 45.

In the arrangement shown in Fig. 4, the auxiliary engine imparting twist to the propeller blades is put out of action when the supply of fuel to the engine falls below the amount corresponding to the setting position B (Fig. 3). With this object there is provided between the delivery pipe 51 and suction pipe 53 of the pump 50 a valve 60 with spindle 61, which opens towards the delivery pipe 51 and is normally pressed against its seat, and therefore closed by the positive pressure obtaining in the delivery pipe. The lever 17, to be adjusted by control rod 22, has an extension 21, projecting beyond its pivotal point 18, and pushing open the valve 60 when the rod 22 is displaced far towards the right owing to a considerable reduction of the fuel supply. In such case, the power piston 42, and accordingly the propeller blade 4 also remain in the position corresponding to the setting B of the fuel supply that is to say in a position corresponding approximately to the blade setting of an ordinary fixed pitch propeller, or even at a somewhat steeper angle.

The effect of the arrangement shown in Fig. 5 is to set the propeller blade at the greatest possible pitch angle when the fuel supply is adjusted to a value B that is smaller than corresponds to the lower controlled speed n_1. With this object the slide-valve rod 28 carrying the collar 29 of the governor is provided with an extension 63, which projects beyond the

lever 17 and carries a stop 64. In setting the fuel supply to "low", the rod 22 is pushed far towards the right, thus causing the stop 64 to be acted upon by the lever 17 and the valve member 45 to be moved accordingly towards the right. Consequently, pressure liquid is enabled to pass to the right hand face of the power piston 42, thus displacing the piston into its left end position and setting the propeller blade 4 at the maximum pitch angle. This necessitates a limitation of the stroke of the piston 42 and of the propeller blade. If said limitation be effected by means of fixed stops, the inconvenience arises that the pump 50 has to act all the time against the high pressure corresponding to the loading on the safety valve 55. Consequently, hydraulic buffers are also provided in the form of valves 65, 66 interposed between the spaces charged with pressure liquid and the return-flow spaces 52, 53. Said valves are provided with spindles 67, 68 which coact with stops 71, 72 seated on the piston rod 40, in such a manner that when one end position has been reached, the valve situated on the pressure-loaded side of the piston 42 is lifted and thus places the pressure space in communication with the return-flow space, so that no further displacement of the piston 42 occurs. In place of valves, other connecting devices such as cocks or slide valves may be employed for limiting the stroke.

In the example shown in Fig. 6 which is otherwise of similar design, to that in Fig. 5, power cylinder 41 and power pistons 42 are themselves constructed for limiting the stroke. With this object the passages 56, 57, connecting the valve casing 46 with the power cylinder 41 are wider than the piston at the point where they open into the power cylinder. If, as shown in the drawing, the control slide 45 be moved fully towards the right by the rod 22, and the right hand passage 57 placed in communication with the delivery pipe of the pump and the left hand passage with the return-flow pipe 52, the pressure liquid flowing through the passage 57 will push the power piston 42 towards the left to such an extent that its right edge uncovers the mouth of the passage 56 in the power cylinder so that the liquid delivered by the pump 50 can now pass directly into the return pipe 52 as indicated by the arrows. Consequently, the delivered liquid loses its pressure and the power piston is therefore not displaced any further. The stroke is limited at the other end by means of the power piston and the widened mouth of the passage 57 leading into the power cylinder. Instead of the power piston a member, such as a special sliding member, in positive connection with said piston or with the blade, could be employed as control member for limiting the stroke.

Such stroke-limiting devices can also be applied in a suitable manner when the twisting of the blades is effected by an auxiliary force other than hydraulic pressure. Thus, for example, when mechanical energy is employed, clutches may be provided; when electricity is employed, so-called limit switches may be inserted.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A screw propeller for use with aircraft and watercraft having an automatic pitch adjustment device for keeping the number of revolutions approximately constant characterised by the fact that the member enabling the speed-sensitive part of the pitch adjusting device to be set for different controlled speeds is coupled with the member serving to vary the fuel supply to the engine in such a manner that reduction of the fuel supply is accompanied by a reduction of the controlled speed and vice-versa.

2. A screw propeller according to Claim 1, wherein the member serving to set the speed-sensitive part for different controlled speeds is also adjustable independently of the fuel supply.

3. A screw propeller according to Claim 1 or 2, wherein the pitch adjustment device includes an auxiliary arrangement which in the event of the propeller speed, owing to extensive reduction in the supply of fuel to the engine, falling below that lower limit of the controlled speed which the pitch adjusting device is still able to keep constant, prevents the pitch of the propeller blades from being reduced below the value existing when the lower limit of the controlled speed is attained.

4. A screw propeller according to Claim 3, having a pitch adjusting device actuated by an auxiliary engine and wherein the conduit or conductor supplying energy to the auxiliary engine is provided with a switching member which shuts off the supply of energy to the auxiliary engine when the supply of fuel to the engine driving the propeller is reduced to such a low value that the corresponding propeller speed is below the lower limit of the controlled speed.

5. A screw propeller according to

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Claims 3 and 4 having hydraulic means for adjusting the pitch and wherein there is provided between the supply pipe and the return pipe of the hydraulic auxiliary engine, a connection controlled by a valve or the like which is opened as soon as the supply of fuel falls below a predetermined low value by the arrangement which serves at the same time for adjusting the supply of fuel to the engine driving the propeller and for adjusting the controlled speed.

6. A screw propeller according to any one of Claims 1—3 wherein the pitch adjusting device includes an auxiliary arrangement which increases the pitch of the propeller blades in the event, owing to extensive reduction in the supply of fuel to the engine, of the propeller speed falling below the lower limit of the controlled speed which the pitch adjusting device is still able to keep constant.

7. A screw propeller according to Claim 6 having a pitch adjusting device actuated by an auxiliary engine wherein the member which controls the supply of blade twisting energy to the auxiliary engine and is set by the speed-sensitive member of the device is equipped with an auxiliary adjusting device for direct adjustment through the member controlling the fuel supply to the engine driving the propeller, in such a manner that the said direct adjustment cannot be performed until the supply of fuel to the engine has fallen below a predetermined limit, and that said adjustment takes place in the direction of increasing the pitch of the propeller.

8. A screw propeller according to claims 7 and 8 having hydraulic means for adjusting the pitch wherein the member controlling the supply and return of the pressure liquid to and from the hydraulic auxiliary engine can be set by the member serving to adjust the supply of fuel to the engine driving the propeller as well as by the speed-sensitive member of the device and that the connection between the hydraulic control member and the member controlling the fuel supply is effected in such a way that the latter member does not set the hydraulic control member until the supply of fuel falls below a predetermined small amount the resulting admission of pressure fluid to the auxiliary engine actuating the latter in the direction of increasing the pitch of the blades.

9. A screw propeller according to any one of the Claims 1—8 having a pitch adjusting device actuated by an auxiliary engine wherein a device is provided which, as soon as the propeller blade has been twisted to the full extent of its prescribed range of variation, shuts off the further supply of energy to the auxiliary engine, thereby stopping the latter and thus preventing the prescribed range of variation from being exceeded.

10. A screw propeller according to Claim 9 wherein the device serving to shut off the supply of energy to the auxiliary engine is formed by a switching member which is in constant positive connection with the adjustable blade.

11. A screw propeller according to Claim 9, having a hydraulic pitch adjusting device wherein the device for shutting off the supply of energy to the auxiliary engine and thereby limiting the range of variation, is in the form of a valve, cock, slide-valve or the like which establishes communication between the supply and return pipes for the pressure liquid as soon as the blade reaches the end of the prescribed range of its adjustability.

12. A screw propeller according to Claims 10 and 11 wherein the hydraulic auxiliary engine is of the reciprocating type and is also designed to limit the range of variation, the passages connecting the cylinder of the engine with a control member for the pressure liquid being wider at their point of entrance into the cylinder than the perimeter surface of the piston in contact with the cylinder wall.

Dated this 7th day of August, 1935.

ABEL & IMRAY,
30, Southampton Buildings.
London, W.C.2,
Agents for the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

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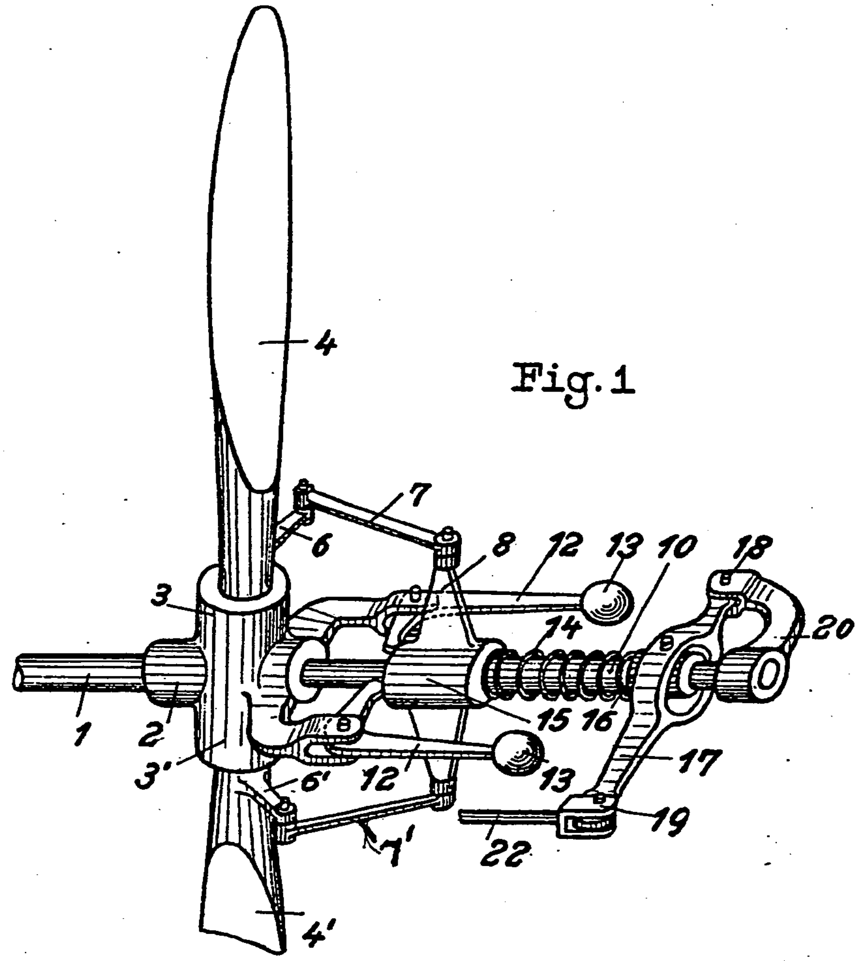


Fig. 1

Fig. 2

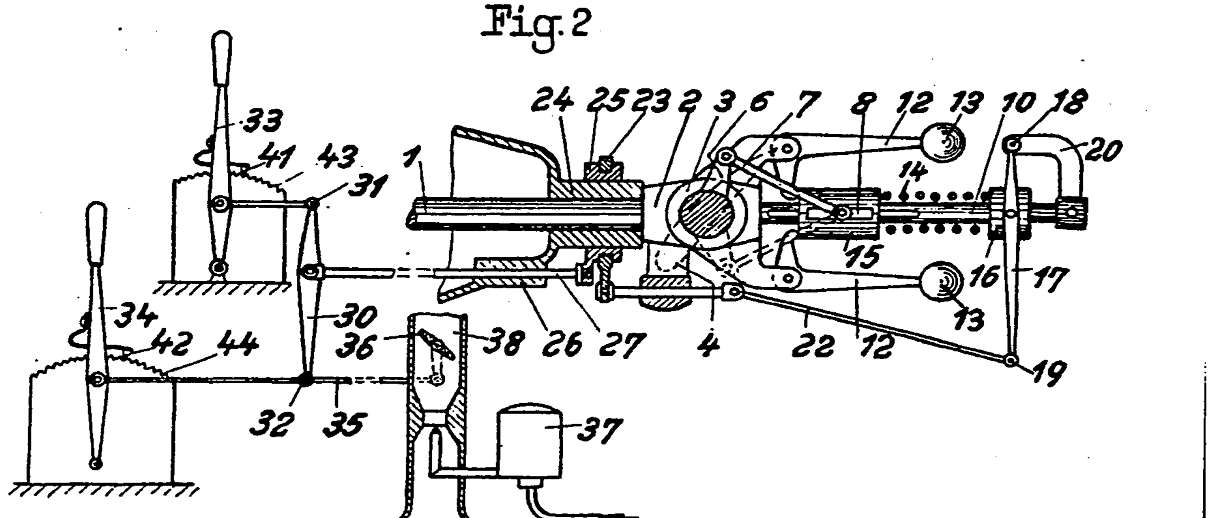


Fig. 3

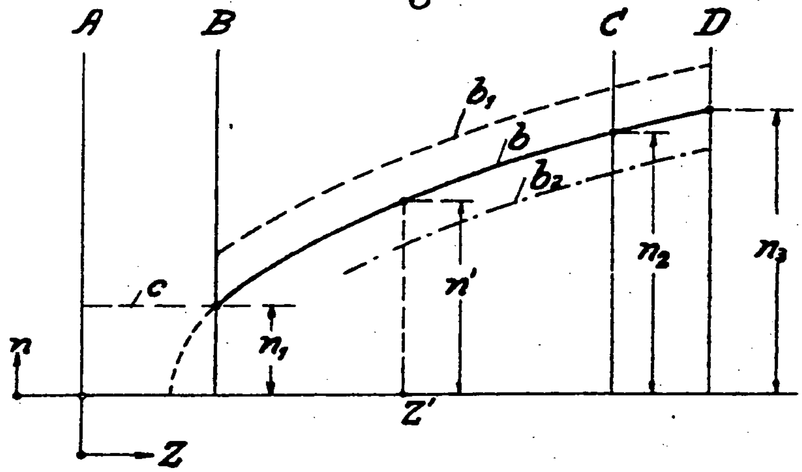
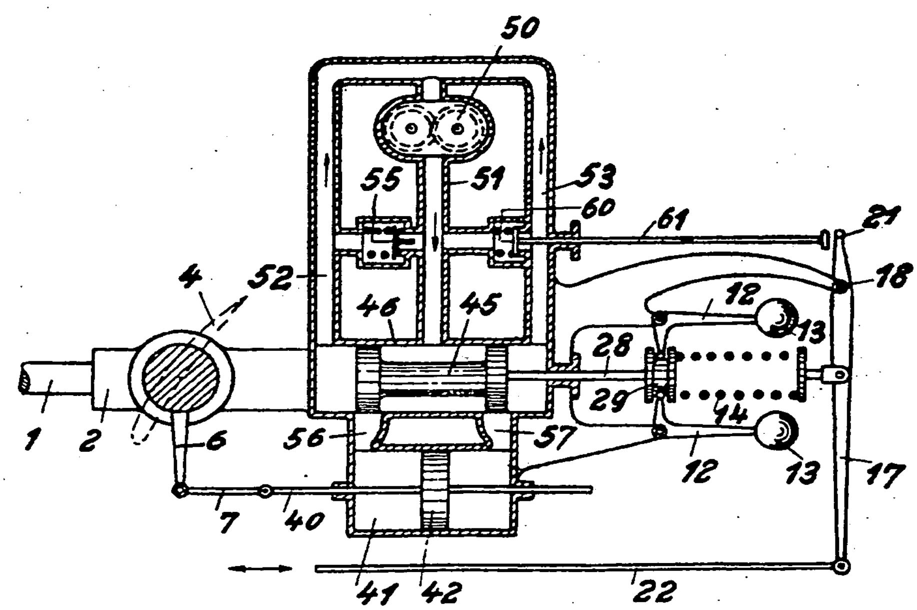


Fig. 4



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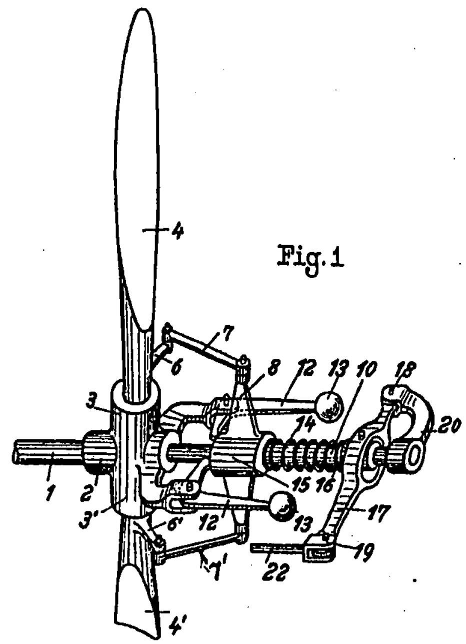

Fig. 1

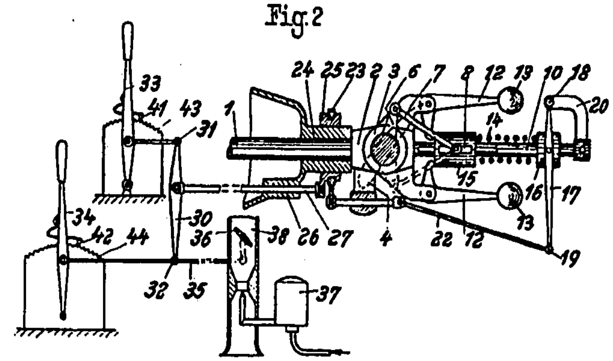

Fig. 2

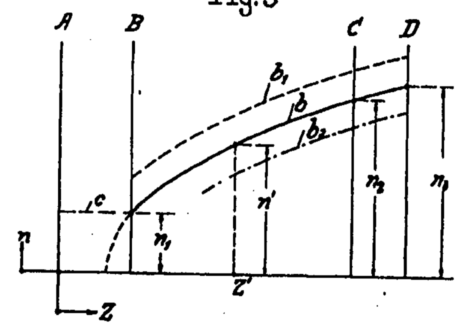

Fig. 3

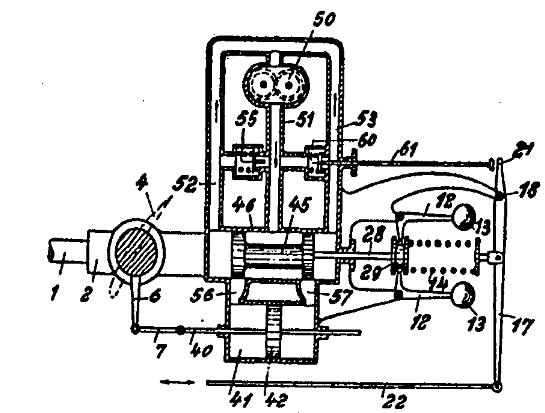

Fig. 4

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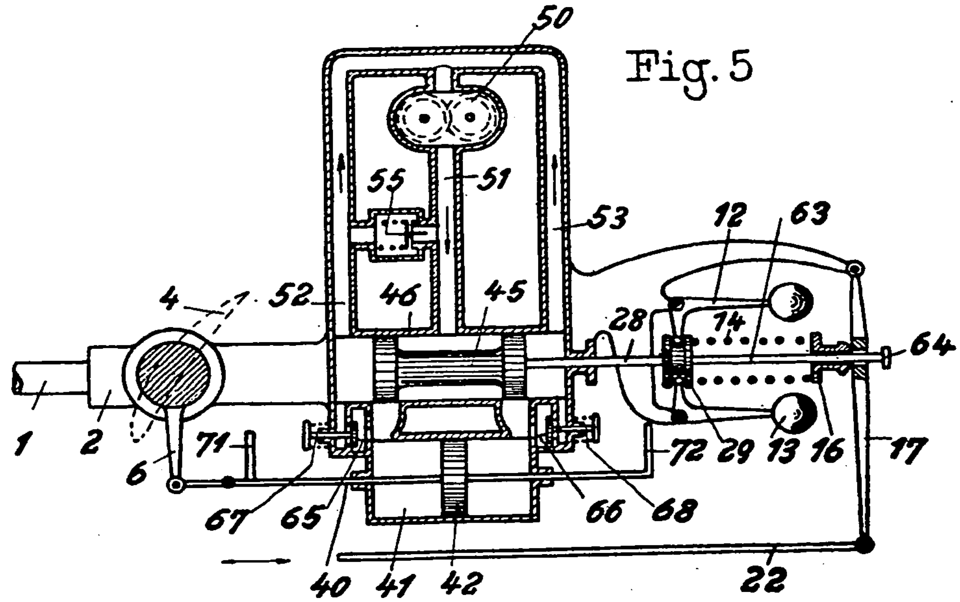

Fig. 5

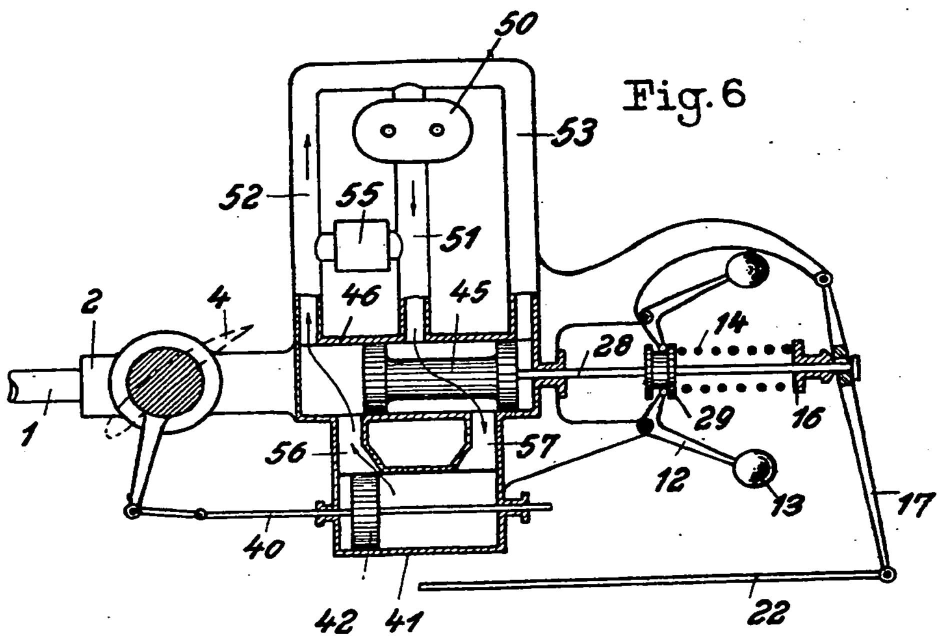

Fig. 6

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Fig. 1

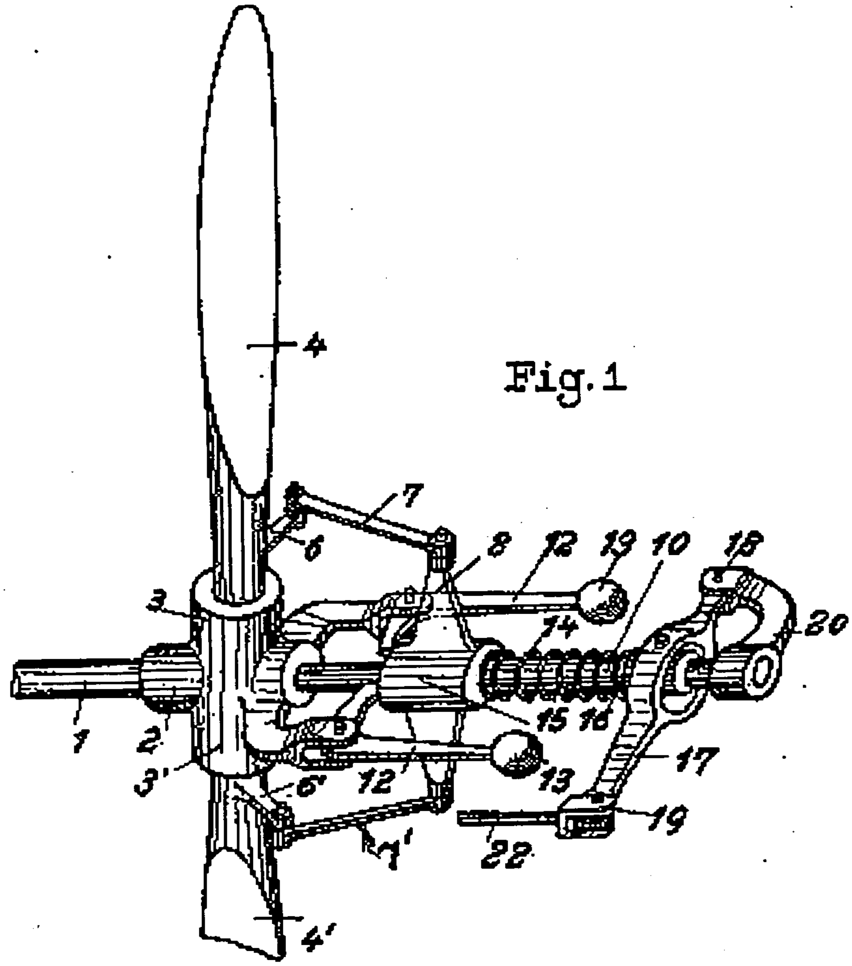

Fig. 2

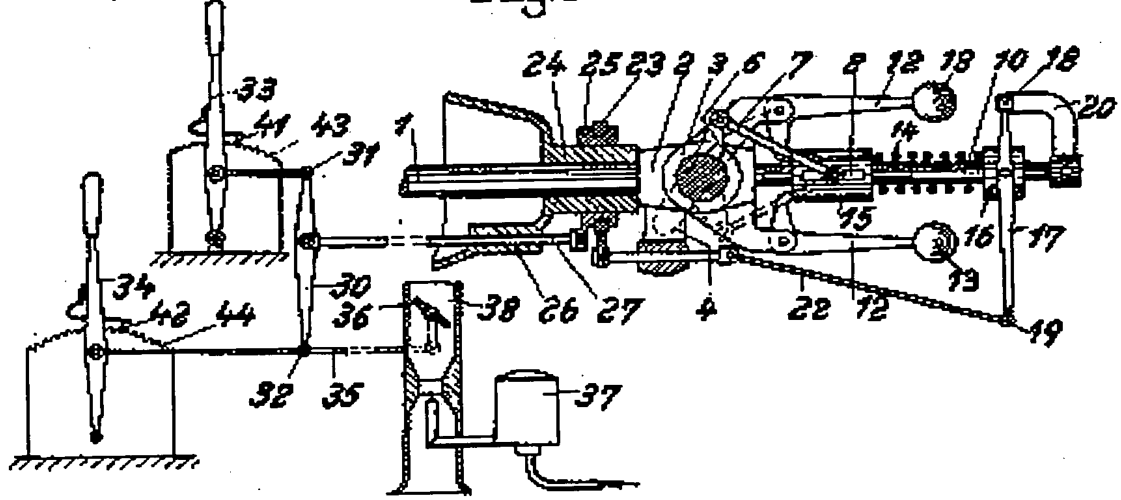

Fig. 3

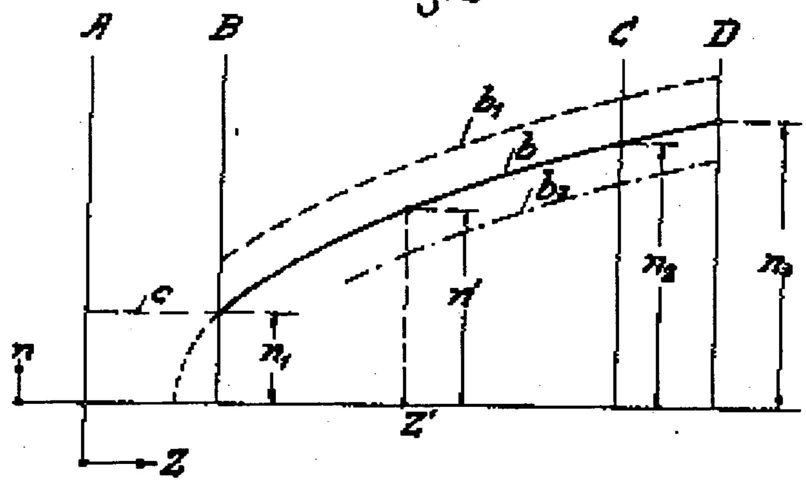

Fig. 4

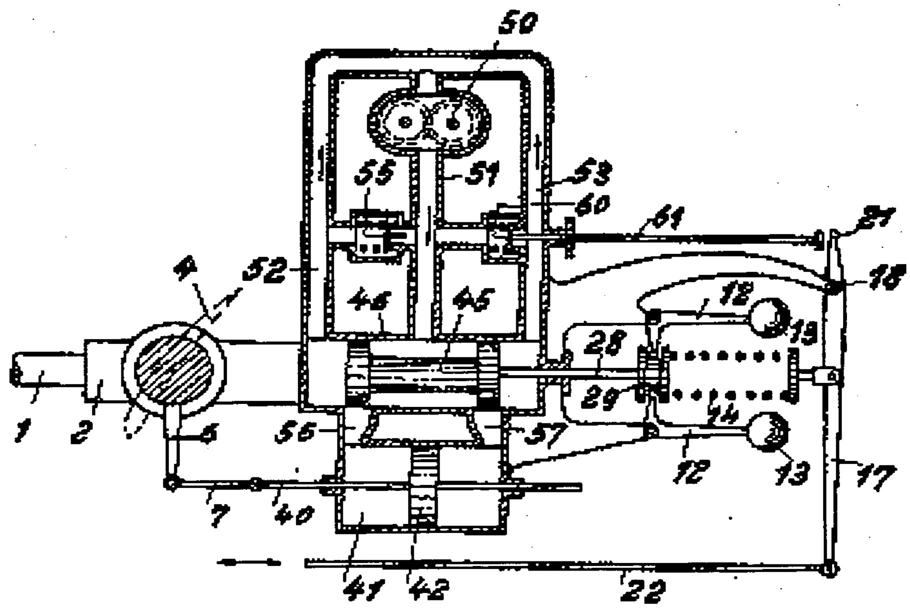

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Fig. 1

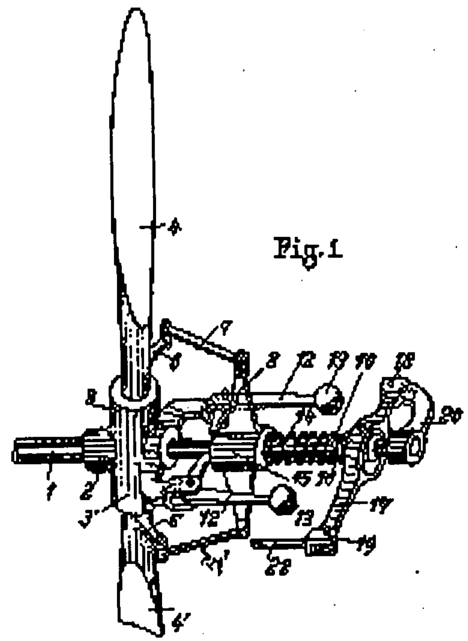


Fig. 2

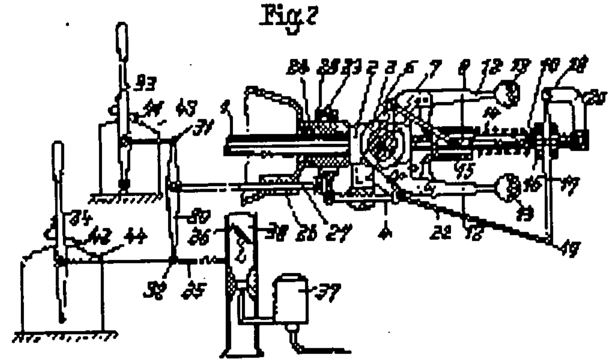


Fig. 3

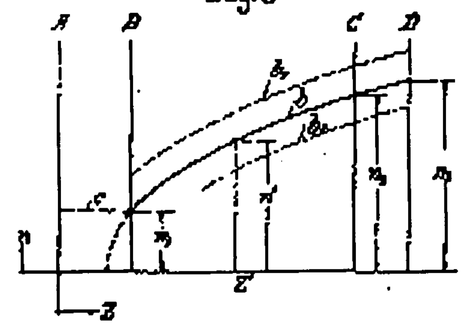
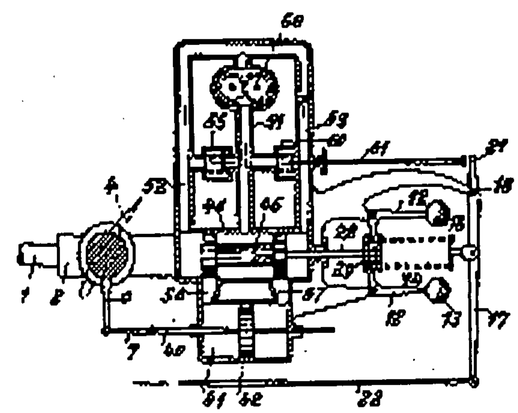


Fig. 4



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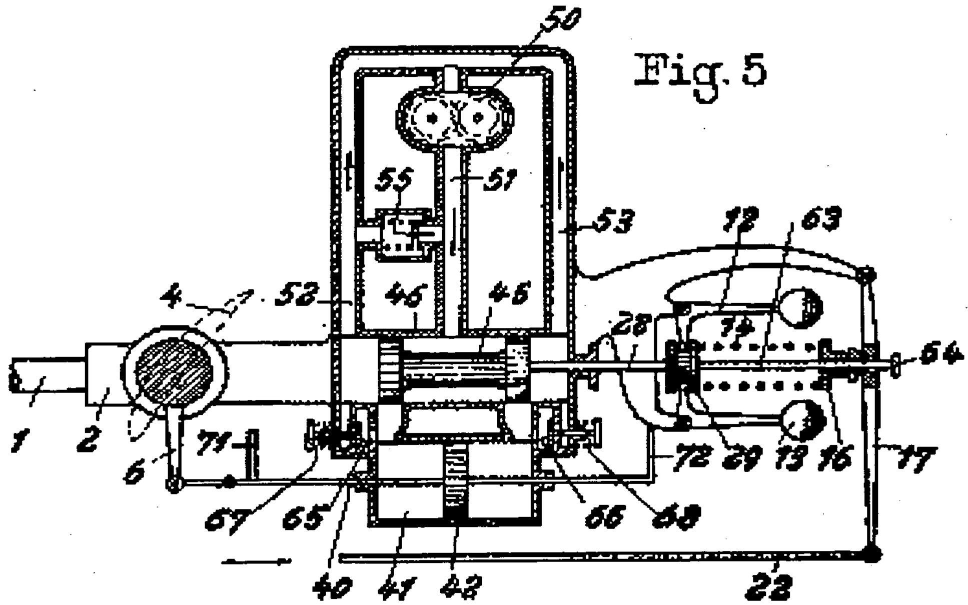

Fig. 5

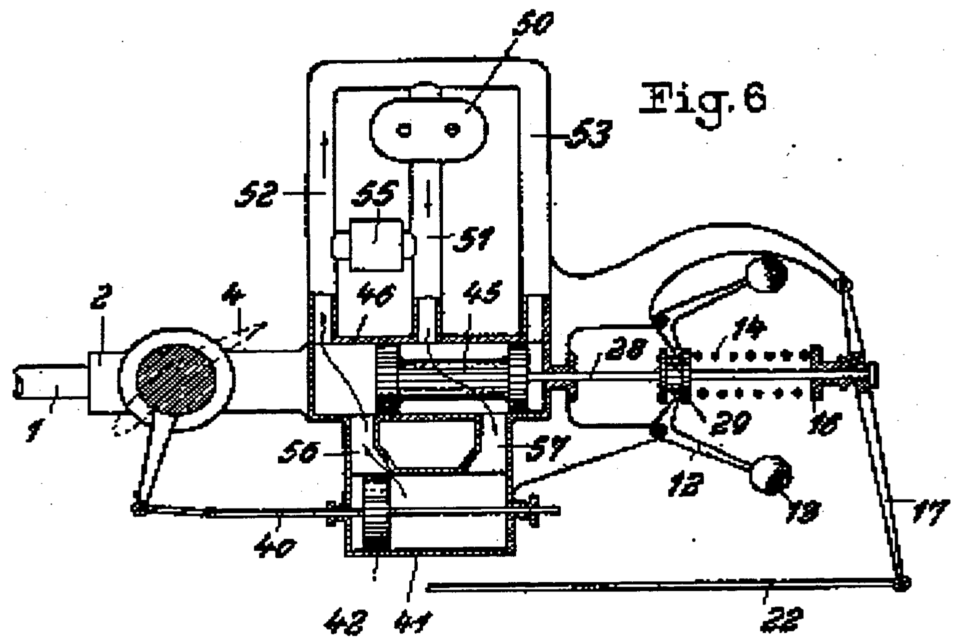

Fig. 6